A study on the social equity of 'Rail + Property' development in Hong Kong

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Abstract

The economic success of Hong Kong's Rail + Property (R + P) development has been widely discussed in academia, but very few studies focus on the social aspect of it. This research on the social equity of Hong Kong's R + P development can help promote Hong Kong's R + P development towards more comprehensive sustainability.

This thesis adopts the quantitative method. Through quantitative research, it is found that the availability of Hong Kong's R + P stations is positively correlated with household income, and is biased towards higher income group. Another result is that the affordability of R + P residential properties is worse than that of overall residences in Hong Kong for low- and middle-income households, and low- and middle-income households cannot afford Hong Kong's R + P residential properties. The biased distribution of the availability of R + P stations and the lack of affordability of R + P residential properties may lead to greater gap between the rich and the poor and inefficient resource allocation etc. This thesis proposes to utilize urban planning intervention, provision of economical public R + P residential properties and financial support to mitigate those social equity issues.

However, more researches are required to focus on other aspects of social equity issues of R + P development in Hong Kong except the availability of R + P stations and the affordability of R + P residential properties. The rationality of the explanation for problems and the effectiveness of the countermeasures also need to be verified by further researches.

Keywords Rail + Property, Social Equity, Rail transit, Hong Kong

Preface

I appreciate Aalto University for giving me a valuable learning opportunity for my master degree at first. In 2018, an acceptance letter from Aalto University linked the life trajectory of a Chinese student to a nation which is located over six thousand kilometers away, Finland. During past days at Aalto University, I studied the major I love, met kind teachers, and made friends from different cultural backgrounds. These experiences will become my fortunes for the rest of my life.

For the writing of this thesis, I would like to thank Professor Elias Oikarinen for being my supervisor and advisor. From the research plan to the content of the thesis, Professor Elias Oikarinen patiently gave me a lot of guidance, help and encouragement. Through the writing of this thesis, my research skills have been improved.

Finally, I need to thank my family and friends who always support and care about me. Because of them, I can concentrate on my studies and enjoy my life as a student.

Contents

1 Introduction

1.1 Research background

Rail transit is one of the main public transportation methods in the world. It is characterized by large investment and high carrying capacity, which can greatly improve the service level of urban public transportation. However, the huge construction investment and operating costs of rail transit restrict its development.

Rail transit construction and operation in Hong Kong is a relatively successful case in the world. As of February 2020, the total mileage of rail transit network in Hong Kong is 262.2km, and the rail system accounts for 42% of the total trips made on public transport each day.[1]About 43% of the employed population and 75% of the commercial and office floor areas are located within a 500-metre radius of a train station (Yin, 2014). Moreover, through the integrated development of rail + property, Mass Transit Railway Corporation (MTRC), which leads the development of rail transit in Hong Kong, has become a profitable rail transit company, which is very rare in the world. From 2014 to 2018, the average annual operating profit of MTRC was HK$19.74 billion and operating gross profit margins reached more than 35% (MTRC, 2019). The above data shows that Hong Kong's rail transit network plays an important role in urban development. Rail transit provides Hong Kong with good infrastructure support for becoming an Asian financial centre. Those financial data indicate that the integrated development model of rail and property (R + P) adopted by MTRC is economically sustainable.

The successful financial practice of Hong Kong's R + P development model has received widespread attention in the industry and academia. This development model has a profound and complex impact on the structure of society by changing the urban economic geographic pattern. However, there is still a lack of academic research on the social aspects of this model.

The development of rail transit has many benefits to society, such as reducing road traffic and pollution, travel time saving, road safety benefits, possible increase in employment opportunities, possible rejuvenation of the older urban areas along railway catchment, reducing health care costs (Tang *et al.*, 2004; Litman, 2007; Stokes *et al.*, 2008). To provide a better level of rail transit services and development sustainability, MTRC adopts the integrated development model of R + P (Tang *et al*., 2004; He *et al.*, 2018). The development of rail transit has improved the accessibility of land and may induce increases in land value, which provides the possibility to capture the added value to fund rail transit (Suzuki *et al*., 2015; Doherty, 2004; Medda, 2012). However, the appreciation of the land around rail stations leads to an increase in housing prices in Hong Kong (Jayantha *et al.*, 2015; He, 2020). Housing prices around rail stations can be too high that some income groups cannot afford; as a result, these groups may be gradually squeezed out of such a prime location that is convenient for rail transportation (He *et al*., 2018; Grube-Cavers and Patterson, 2015). In this process, different social groups face different costs and benefits.

1.2 Research purpose

1.2.1 Research questions

The development of Hong Kong's rail transit by adopting the R + P development model has

[1] Transport Department, The government of Hong Kong Special Administration, 2020.

not only provided a high level of public transport services which has a strong externality and increases the welfare of the entire society, but also achieved financial sustainability. However, the development of rail transit networks will profoundly change the urban economic geographic pattern. This change will produce different gains and losses for different groups, thus affecting social equity.

This thesis aims to explore the social equity of R + P development model by studying the impact of changes in the urban economic geographic pattern caused by the R + P development on different groups in society, and expand the insights of R + P development model from the perspective of social sustainability. There are many types of real estate involved in the R + P development. This thesis discusses two types: R + P stations and R + P residential properties. R + P stations are rail stations formed through R + P integrated development. R + P residential properties refer to the integrated development real estates, which are stipulated for residential use. The focus of this thesis will be on the social equity of R + P development for different income groups in Hong Kong, which is reflected by the relationship between the availability of R + P stations and household income, and the affordability of R + P residential properties for low- and middle- income group.

The specific research questions studied in this thesis are: How is the availability of R + P stations distributed among different income groups? What is the relationship between the availability of R + P stations and household income? How affordable are the R + P residential properties? Can low- and middle-income households afford the price of R + P residential properties?

1.2.2 Hypotheses

This thesis has the following two sets of hypotheses:

a. The higher income group has higher availability of R + P stations, and the availability of R + P stations for households has a positive correlation with the income level of their district.

b. The affordability of R + P residential properties is worse than that of overall residences, and low- and middle- income groups cannot afford the price of R + P residential properties.

1.3 Research method and research data

When studying the availability of R + P stations and the affordability of R + P residential properties, quantitative research methods were applied, including classification statistics and correlation analysis etc. The data used in this thesis mainly comes from statistical reports published by authoritative departments, consulting companies, and other academic papers.

1.4 Structure

This thesis is divided into five sections:

I. Literature review
This section mainly reviews the land value capture theory, the articles about Hong Kong's R + P development model and the researches of social equity. Land value capture is the theoretical basis of Hong Kong's R + P development model. It is found that most researches focus on the economic aspect of the R + P development model. Very few studies are found on the question of its social aspect. Therefore, this thesis aims to study social equity of R +

P development model in Hong Kong. Finally, concepts, history, research direction of social equity and literature on social equity in the development of public transportation are reviewed.

II. Methodology description
This section mainly presents the choice of philosophical worldviews, research methods, data collection and research process. This thesis adopts the pragmatic worldview and quantitative research methods. Public and open data are the main data source. The research process section describes the research ideas and specific steps.

III. Results
This section presents four results: first, the distribution of R + P station availability for each income group; second, the correlation between R + P station availability and household income level; third, the affordability of R + P residential properties measured by Price-to-Income Ratio (PIR); fourth, the affordability of R + P residential properties measured by Housing Affordability Index (HAI).

IV. Discussion
First, the research questions and results are emphasized again in this section. Second, the causes of results are explained. Then, problems reflected by the results are revealed, and possible countermeasures are proposed. Finally, the limitations of the research and possible future research directions are presented.

V. Conclusion
This section summarizes the whole research.

2 Literature Review

The costs of rail transit construction and operation are huge. Ticket revenue and financial subsidies from the government are usually insufficient to cover these costs. As a result, land value capture has gradually become a financing instrument for rail transit development in many cities. MTRC has created a unique R + P development model based on the theory of land value capture, which has achieved great economic success. Scholars have conducted a considerable number of researches on the R + P development model from different perspectives. The Department of Construction and Real Estate Economics of The Hong Kong Polytechnic University is entrusted by MTRC to conduct a relatively comprehensive and systematic research which includes both theoretical and empirical studies on the R + P development model (Tang *et al*., 2004). Cervero and Murakami (2009) studied the impact of R + P development model on housing prices and ridership. Xue and Sun (2018) investigated the development ratio which indicates the density, effectiveness and efficiency of a rail station catchment area. Most of these studies focused on the economic aspects of the R + P development model.

2.1 Review of land value capture theory

Land value capture theory is the theoretical basis of R + P development model. When selecting a site for a rail station developed by the R + P model, it is usually necessary to fully consider the potential of land value increase and the feasibility of capturing value to finance rail transit construction. Reviewing the land value capture theory helps to understand the distribution of R + P stations and their relationship with household income. In addition, land value capture theory also helps explain the developer's strategy for developing and pricing R + P residential properties, which usually results in higher housing price.

Land value capture is not a very new concept. In 1821, the basic idea of land value capture was mentioned in David Ricardo's writing. The value of land is determined not only by intrinsic value and private investment, but also by other external factors including changes in land-use rules, public investment in infrastructure, local services, total population and economic development (Suzuki *et al*., 2015). Figure 1 shows the different components of land value and beneficiaries (Hong and Brubaker, 2010). It should be noted that the descriptions in Figure 1 are just the authors' opinion and numerous parties do not necessarily agree with that.

Theoretically, land value capture is to obtain the added value of land induced by external factors. Land value capture mainly relies on the increase of land prices near public transportation facilities. When market conditions are conducive to public transport policies, public transport investment will generate external benefits including accessibility enhancement and agglomeration effects, which will be capitalized in the land near public transport facilities. A large number of studies in the past have shown that investment in rail transit can increase land or property values.

Gibbons and Machin (2005) studied the construction of new stations in London in the late 1990s to evaluate the benefits of rail access, which shows that consumers do strongly value better rail access. Although there is no precise number, distance-to-station effects are significant in terms of housing price determination. There may be two reasons for this positive effect. First, better rail access can save travel time for passengers. Second, rail access

reduces commuting cost to more diverse, productive, and higher-paying jobs. However, there are also negative environmental externalities such as noise and congestion near the station. It should be noted that Gibbons and Machin (2005)'valuation includes the benefits of travel time savings and any other benefits of living nearer to stations, net of any changes in environmental or social factors such as increased noise or higher crime rates. Therefore, in general, positive capitalization effects of proximity to rail stations in housing values is demonstrated.

Hess and Almeida (2007) analyzed the impact of proximity to light rail transit stations on residential property values in Buffalo, which is a slow-growth city with steep economic decline and staggering population loss in the past several decades. Their study used the hedonic model which suggests that for typical homes located within one-quarter of a mile of a rail station, every foot closer to a light rail station increases average property values by $ 2.31 or $ 0.99 when adopting different distance respectively, whereas other independent variables in the model, such as the number of bathrooms, size of the parcel and location on the Eastside or Westside, are more influential than rail proximity in predicting property values (Hess and Almeida, 2007). This result shows that the impact of proximity to the station is not always very significant, which is contrary to Gibbons and Machin (2005)'s research. Besides, the proximity effects of the 14 light rail station areas vary according to income level.

Pan (2019) employed spatial regression models together with the widely used ordinary linear regression (OLS) and the sophisticated multi-level regression (MLR) model to investigate the impacts of the light rail system on residential property values in Houston which is the largest non-zoning city. Houston's light rail has significant positive effects on the values of nearby residential properties 6 years after the commencement of its services, which cannot be identified within a 3-year time span in the studies by Pan and Ma (2009) and Pan (2013). Pan (2019)'s research illustrates that the effects of rail transit on property values in a non-zoning city are similar to other zoning cities.

Diao *et al*. (2017) conducted a study on the effects of urban rail transit networks on non-landed private housing values in Singapore, which shows that prices of houses within the 600-metre network distance from the new Circle Line (CCL) stations increase by 10.6% relative to houses located beyond 600-metre network distance after the opening of the CCL using the static diff-in-diff models. After incorporation of a spatial lag term (SAC), a spatial error term (SARAR) in spatial diff -in-diff (SDID) models, the magnitude reduces to 8.6%. Previous studies usually apply the hedonic price model (HPM), which is vulnerable to the problems relating to omitted variables and endogeneity issues, to examine effects of the rail transit station on property values, whereas Diao *et al*. (2017)'s article applies innovations in spatial econometric tools to address the issues of spatial dynamics and spatial dependence structure, and thus improve the quasi-experiment approach in capitalizing the rail transit effects.

However, some researchers have found that the connection between public transportation and land values is weak, mixed, or even negative. This difference is partly due to the methodological differences and quality of data, and it could also be the negative impact of public transport such as noise, air pollution and crime etc.

Gatzlaff and Smith (1993) found evidence that residential property values only weakly

impacted by the announcement of the new rail system in Miami, by comparing repeat-sales indices and using hedonic regression methods. The impact of rail development on house values does not follow the distance between the house and the station, but varies according to different neighbourhood types.

Diao *et al*. (2016), investigated the impact of the cessation of the Keretapi Tanah Malaya (KTM) railway services between Malaysia and Singapore to reveal the effects of noise externalities on housing prices. Based on the difference-in-differences (DID) framework, average prices for houses located within a 400-metre noise zone from the railway lines increased by 3.5% relative to prices for houses located outside the 400-m boundary after the cessation agreement has been announced, and increased by 13.7% on average after the cessation agreement took effect in July 2011 (Diao *et al*., 2016). However, Diao *et al*. (2016)'research directly using distance to the rail line as the identification for noise externalities, which is too simplistic. Although the article stated that other confounders associated with being close to train stations were not found, the railway line can have other potential negative factors on residential properties for being within 400 metres such as the negative impact on the layout of houses and surrounding traffic. The neglect of those factors may exaggerate the negative effects of noise on nearby residential properties.

In addition to the researches focused on the single-direction (positive or negative) effects, A more comprehensive and fundamental perspective is needed. Bowes and Ihlanfeldt (2001) explored the impact of rapid transit stations on residential property values within the Atlanta region. Their study comprehensively considered four types of factors: access advantage provided by rail stations; negative externality effects emitted by the station, such as noise, pollution; the neighbourhood commercial services attraction; crime. Among them, the former two factors are collectively referred to as direct effects, whereas retail effects and crime effects are collectively called indirect effects. Research conclusions indicate that direct effects are generally larger in absolute value than crime or retail effects; retail effects are larger than crime effects, except in the immediate vicinity of stations located close to downtown; and total effects vary a great deal with neighbourhood income level, distance to downtown, and distance from the station (Bowes and Ihlanfeldt, 2001). Their research reveals that the impact of the rail station on its surrounding residential properties value depends on the competition between the contradictory factors, which provides a basis for a more comprehensive feasibility analytical framework of the land value capture for rail transit investment.

The choice of model also has a significant impact on the research conclusions. Most relevant studies adopted the hedonic price model (HPM) introduced by Rosen (1974) to evaluate the effects of rail transit (Gatzlaff and Smith, 1993; Bowes and Ihlanfeldt, 2001; Sharma and Newman, 2018; etc.). However, the utilization of cross-sectional data by HPM may produce biased conclusions because there may be important features that are omitted. The DID model is a relatively simple method to avoid omitting variables, so it has been applied by many recent studies (Wagner *et al*., 2017; Ransom, 2018; Diao *et al*., 2017; etc.). In addition, Geographically Weighted Regression (GWR) model have also been employed by Zhong and Li (2016) and Mulley *et al*. (2018) with more recent data, which can provide more reliable conclusions.

Summarized in Table 1, researches on the impact of rail investment on property values provide a fundamental reference for the land value capture of railway project construction

and operation. However, these Researches are only concerned about micro factors. Macro factors, regulatory and institutional factors, public transport technologies, networks, alternative travel methods and socioeconomic disparities can also affect the value of land near public transportation facilities (Suzuki *et al*., 2015).

Table 1

Summary of studies for the impacts of rail transit on residential property values				
Author (date)	**Location (the United States unless otherwise stated)**	**The type of rail**	**The time period of price data used**	**Estimated influence of rail on property values**
Gatzlaff and Smith (1993)	Miami, Florida	Heavy rail system	Between 1971 and 1990	The property value weakly impacted by the announcement of the new rail system.
Bowes and Ihlanfeldt (2001)	Atlanta, Georgia	Rapid transit	From 1991 to 1994	Total effects of rapid transit on property value vary a great deal with neighbourhood income level, distance to downtown, and distance from the station
Gibbons and Machin (2005)	London, UK	Underground and light rail	From 1997 to 2001	Significant positive capitalization effects of proximity to rail stations in housing values are demonstrated.
Hess and Almeida (2007)	Buffalo, New York	Light rail	2002	For typical home located within one-quarter of a mile of a rail station, every foot closer to a light rail station increases average property values by US$2.31 or US$0.99 when adopting different distance respectively.
Diao *et al.* （2016）	Singapore	International rail	From January 2005 to June 2013	After the cessation agreement took effect in July 2011, prices for houses located within KMT the noise zone increased by 13.7% on average relative to other houses located outside the KTM noise zone.
Zhong and Li (2016)	Los Angeles, California	Light rail and heavy rail	During 2003 and 2004	Proximity to mature rail transit stations generally benefits multi-family property values, but the effect is negative for single-family properties. The premiums for rail transit accessibility also largely depend on different development

				phases and can be heavily discounted by the existence of Park-and-Ride facilities.
Diao *et al.* (2017)	Singapore	Mass Rapid Transit	From April 2007 to March 2013	The opening of the CCL increases the value of houses located within the 600-metre network distance from the new CCL stations by approximately 8.6%.
Wagner *et al.* (2017)	Norfolk, Virginia	Light rail	From July 2002 to August 2016	Properties within 1500 metres experienced a decline in sale price by nearly 8%, while the sale-list price spread decreased by approximately 2%.
Ransom (2018)	Seattle, Washington	Light Rail	Between January 1, 1992 and March 31, 2016	There is little evidence that light rail service provides value to the neighbourhood.
Sharma and Newman (2018)	Bangalore, India	Heavy rail	From 2012 to 2016	The urban rail has substantially increased property values, even beyond the traditional 500-metre catchment. Results show a price uplift of 4.5% across the whole city after the commencement of the metro rail operations.
Pan (2019)	Houston, Texas	Light rail	From 1982 to 2010	Significant positive effects on the value of residential properties near light rail stations after six-year services in the largest non-zoning city.

Land value capture is usually used as a financing instrument for the construction and operation of public transportation systems. According to the beneficiary pays principle, the beneficiaries of transportation improvement can be divided into three categories: the public, public transportation users, and property owners and developers (Lari *et al*., 2009). The government can choose different financial instruments to recover the capital investment and service cost according to the characteristics and timing of the benefits received by each beneficiary, as shown in Table 2(Suzuki *et al*., 2015). Land value capture as a financing instrument can be used to recover part of the cost from the property owner or developer by capturing the increased land value induced by public transportation infrastructure investment. Land value capture instruments are divided into two major types: the tax- and fee-based and the development-based (Suzuki *et al*., 2015). The most common tax- and fee-based instruments include land tax, property tax, betterment charges and tax increment financing

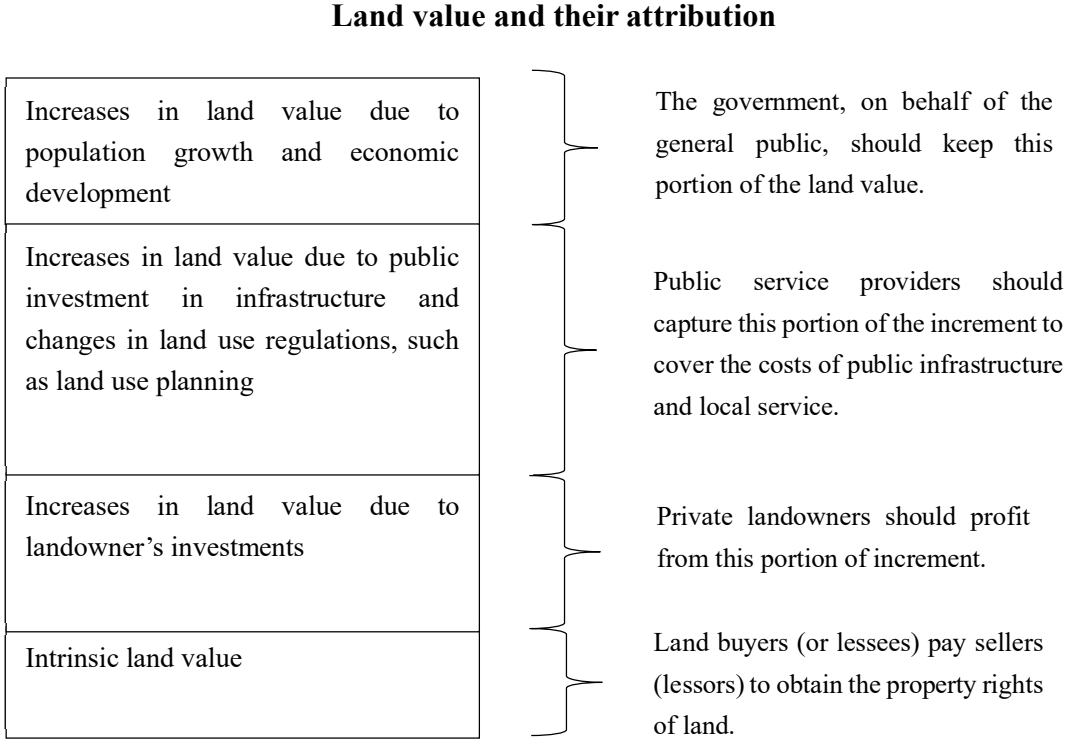

Figure 1 (Hong and Brubaker, 2010)

etc.; development-based instruments include the sale and lease of land near public transportations facilities, joint development by the public and private sectors, land readjustment, and urban redevelopment scheme etc. (Suzuki *et al.*, 2015). Hong Kong's R + P development model is a development-based land value capture instrument.

Table 2

Application of the beneficiary pays principle to urban transport finance			
Beneficiary categories	**Benefits of transport improvement**	**Financial instrument**	**Rationale for use**
Public	Broad economic and social return, such as economic development and growth	Government's general fund	Broad economic growth provides the base for general taxation
Transport users	Reduced travel time and costs; improved travel comfort and enhanced safety	Direct or indirect user charges	Benefit attributed to the users of transport facilities
Property owners and developers	Increased property values	Various value capture or development charges	Benefits are land value increase due to public investments for transport

Source: Lari *et al.*, 2009

2.2 Studies on Hong Kong R + P development model

The Research Centre for Construction & Real Estate Economics of The Hong Kong Polytechnic University conducted a relatively comprehensive and systematic study on the Integrated R + P Development Model in Hong Kong in 2004 (Tang *et al*., 2004). The main objectives of the study are: **a.** How effective the integrated R + P development model in promoting urban development in Hong Kong is. **b.** The key factors and conditions that are conducive to the successful implementation of the R + P development model in Hong Kong. **c.** How the R + P development model can be replicated elsewhere, especially in cities in mainland China (Tang *et al*., 2004). This study embodies the impact of the R + P development model on the urban development of Hong Kong and clarifies the connection between the R + P development model and the urban development of Hong Kong. After the research on the factors and conditions for the successful implementation of the R + P development model, and comparing the rail transit development models of other famous cities in the world, the results show that some external urban factors and complementary government policies are essential institutional factors in contributing to the success of the R +P development model (Tang *et al*., 2004). The study focuses more on the R + P development model itself.

In addition to the study on the model itself, some other scholars also studied the evaluation indicator of the efficiency of R + P development model and the actual effects after the development is completed. Xue and Sun (2018) studied the cases in Hong Kong from the mid-1990s to 2015, and developed an indicator which is named **development ratio (R)**. R is calculated as Formula 1.

$$R = \frac{the\ total\ floor\ area\ of\ the\ rail\ catchment\ area}{the\ floor\ area\ of\ the\ station} \qquad (Formula\ 1)$$

The floor area of the station is measured from the building floor plan (Xue and Sun, 2008). Not all buildings in the rail catchment area counted. The total floor area of the rail catchment area only includes the development resulting from the construction of the station. R indicates the efficiency and density of land use. The larger the R value, the more efficient the land use is, which means more influenced development around the station. The indicator R also has some problems. For example, stations tend to be larger in terms of floor area in some cities or countries; as a result, R is smaller even if the influenced floor area in the catchment area is the same. Indeed, R indicator is not perfect and applicable everywhere. However, in general, the larger the floor area of station designed, the larger floor area of the catchment area is. Some cities and countries may have preference to larger space of stations, but this still seems to be considered as a problem of land use efficiency. The catchment of Kyoto Station in Japan has an R value of 20 (Hui, 2011), whereas most Hong Kong MTR stations have a value of over 20 (Xue and Sun, 2018). The ratio provides a useful and direct figure for the comparison of different stations, cities and development modes.

Cervero and Murakami (2009) found that R + P stations with transit-oriented design usually have an average increase of 35,000 passengers on weekdays in their research paper, and properties developed with rail stations have price premia over 5% compared with non-R + P properties. Cluster analysis was used, which identified five types of R + P project among the 25 MTR stations. Despite the existence of some institutional barriers in different cities, Hong Kong's R+P development model is still beneficial for financing railway infrastructure and

advancing the application of transit-oriented design in cities in mainland China.
Some scholars proposed a new model for investigating the effects of integrated R + P development on the design of rail line services in a linear monocentric city (Li *et al*., 2012). Based on the assumptions, the proposed model offers some important findings. The model indicates that the increased net profit from an R + P scheme can motivate private rail operators to invest in rail line services, but can also cause inefficient urban expansion in terms of average passenger travel time (Li *et al*., 2012). Moreover, residential density and household income level have an important effect on the economic viability of the integrated R + P scheme (Li *et al*., 2012).

The above studies discuss the R + P development model from an economic perspective. As a major public transport development model in Hong Kong, the sustainability of it needs to be studied from a broader perspective. Economic, social and environmental sustainability are the three pillars of sustainable development. However, research on the R + P development model from the perspective of society and environmental protection is relatively lacking. The lack of such research will put Hong Kong and cities learning and replicating Hong Kong's R + P development model in a position that exposes to potential sustainability risks.

2.3 Social equity perspective

Regarding the origin of social equity, Rutledge (2002) pointed out that the concept of social equity can be traced back to the writings of Aristotle, Plato and Wilson, but he tends to link the origin of social equity and public administration with Minnowbrook I. Minnowbrook I conferences convened by Dwight Waldo, George Frederickson, and a group of young Turks in the 1960s. This conference was organized to understand whether younger people in public administration had perspectives on pressing issue of the turbulent time in the 1960s.

Conventional or classic public administration pursues efficiency and economy. At the height of the social turbulence of the late 1960s and early 1970s, Frederickson and Waldo and others advocated introducing social equity as the third pillar besides efficiency and economy into public administration, and established the New Public Administration (Frederickson, 2010). Although the word 'equity' appears in the original Woodrow Wilson (1887)'s essay and other public administration classics, Frederickson (1971) first proposed a relatively full elaboration of the concept of social equity and its application to public administration in the article "Toward a New Public Administration" of Minnowbrook I Conference. Frederickson (2010) wrote in his book that "social equity is now a better understanding of a set of values and preferences, a clearer array of policies and procedures, and a steadily growing body of research based on analysis."

Regarding social equity, The Standing Panel on Social Equity in Governance of the National Academy of Public Administration (NAPA, 2000) gives an operational definition. NAPA defines social equity as "The fair, just and equitable management of all institutions serving the public directly or by contract, and the fair and equitable distribution of public services, and implementation of public policy, and the commitment to promote fairness, justice, and equity in the formation of public policy".

These discussions triggered the thinking of the core value of public administration and public policy from efficiency to social equity. More and more scholars associate social equity with more specific matters in public administration. Thomas and Hwang (2003) studied the social equity in urban redevelopment and housing. They thought social equity relates to the fair

treatment of differing populations, particularly those that have historically experienced disadvantages because of external characteristics. Thomas and Hwang (2003) discussed the significance of three dimensions of social equity in urban redevelopment, including just compensation, public participation in decision-making, and the fairness of the benefits of government projects distributed among various groups in society. Some other scholars have studied the equity of urban rail transit development. The positive effects of transit-oriented development have been reflected in the planning practices of different countries and cities, but from a broader policy perspective, transit-oriented development has also caused some inequities in different social groups while transportation services have been improved (Ricciardi *et al*., 2015; Litman, 2002). Studies also show that car-free and low-income groups are significantly more dependent on public transportation (Welch, 2013). Transit-oriented development often leads to added value of land or housing, which requires more consideration of the affordability of low-income groups (Zakowska and Pulawska, 2014). The issue of land value capture and housing affordability is also mentioned in the book by Suzuki *et al*. (2015). It is written in the book that some people think that the R + P approach has exacerbated the issue of housing unaffordability and socioeconomic segregation.

The social science research literature on social equity has not only begun to be more connected with specific public affairs, but also signalled a steady shift in emphasis (Frederickson, 2010). Concerns about race and gender have been at the core of the study of social equity for several decades, modern social equity scholarship is shifting the central axis of scholarship distinctly in the direction of social class (Frederickson, 2010). In addition, there are more and more attentions on other important inequities such as sexual orientation, religion, region, disability status, immigration status, veteran's status, and language of origin (Frederickson, 2010).

2.4 Summary

Hong Kong's R + P development model is based on the land value capture theory. It is considered as an indirect development-based land value capture instrument. Many scholars have already studied the R + P development model from the perspective of financial sustainability. In many cities, rail transit network becomes a major public goods, and cannot be neglected by modern public administration practitioners. The issue of social equity during and after its development deserves more attention from academia. Some scholars have started to mention the issue of social equity in their research on R + P development. Based on these studies, this thesis will focus on the social equity of Hong Kong's R + P development model in two dimensions: the availability of rail stations developed through R + P model and affordability of R + P residential properties for different income groups.

3 Methodology description

3.1 Philosophical worldviews

Scholars who study different fields may have different worldviews, and even scholars who study the same field may also adopt different worldviews. The choice of worldview has a crucial influence on the research method. Creswell (2014) highlights four philosophical worldviews that are widely discussed in the literature: post-positivism, constructivism, transformative, and pragmatism.

Post-positivism is sometimes called the scientific method. Post-positivists hold a deterministic philosophy in which causes (probably) determine effects or outcomes (Creswell, 2014). Social constructivists that have the constructivism worldview believe that individuals seek understanding of the world in which they live and work (Creswell, 2014). The occurrence of events and the operation of the world do not depend on a unified objective law, but differ according to different people's understanding. Therefore, the social constructivists' intent is to make sense of (or interpret) the meanings others have about the world. Scholars holding transformative worldview believe that research inquiry needs to be intertwined with politics and a political change agenda to confront social oppression at whatever levels it occurs (Mertens, 2010). Pragmatists have no specific philosophy and are not limited to any specific method, but only focuses on whether the problem can be solved. Instead of focusing on methods, pragmatic researchers emphasize the research problem and use all approaches available to understand the problem (Rossman & Wilson, 1985).

From the perspective of pragmatism, this thesis aims to study the social equity of Hong Kong's R + P development with the goal of social sustainability. Social equity is a social concept, it is the nature of human society itself rather than a natural object. There are differences in people's understanding of social equity, and social equity is also an important political issue, so complete post-positivism is not applicable. However, many tools of post-positivism are helpful in studying this topic. This thesis will take advantage of statistics and models to present a relatively objective social equity situation of the Hong Kong's R + P development, analyze and explore the problems and possible countermeasures of the R + P development to increase the social sustainability. This will help to increase the understanding of the R + P development from the social sustainability perspective and promote the R + P development towards more comprehensive sustainability.

3.2 Research methods

Research methods can usually be divided into quantitative method, qualitative method and mixed method. Quantitative method is based on statistics, while qualitative method is based on description. The mixed method is a combination of qualitative and quantitative method. In this thesis, the quantitative method is adopted. Social equity is a relatively subjective concept because it is difficult to give absolute judgments on whether society is equitable or not. Different respondents may give different answers based on their own experience and cognition. It seems that quantitative method is difficult to apply to such research topics. However, research on social equity does not necessarily need to define what is equity or judge whether society is fair or not. Researchers can do some quantitative research to demonstrate the state of social equity through data and analysis. This thesis does some quantitative research on the social equity of Hong Kong's R + P development, and draw conclusions through analysis to help better understand the social equity of R + P

development, then propose some suggestions and possible countermeasures to the problems.

3.3 Data collection

In this thesis, the research on social equity of the R + P development in Hong Kong mainly uses data from the Census and Statistics Department of the Hong Kong government, consultancy, and academic researches on the R + P development in Hong Kong.

The Census and Statistics Department of the Hong Kong Government provides very detailed and open statistics data, including population and household statistics analyzed by District Council districts, and Hong Kong median household income reports etc. These data are considered to be quite reliable. The housing price data from Wendell Cox Consultancy (Demographia) is also used in this thesis. Although based on legal liability considerations, the data provider stated that it does not provide any guarantee for the accuracy of the data, but the data is almost the most detailed data source available from public sources, so the author believes that the data from the consultancy has reference value. This thesis also cites the data about the number and distribution of R + P stations from Cui (2019)'s article, these data also have certain reference value.

It should be noted that this thesis does not collect and use first-hand data for two reasons. First, the data required for the researches in this thesis can be found from relatively reliable and open sources, so there is no need to repeat basic works, but directly utilize the results. Second, only public sector and professional data providers have sufficient capability to acquire certain data such as income data, house price data, etc.

3.4 Research process

The key point of social equity is fair treatment of different social groups. For the study of social equity, it is difficult to quantitatively describe what is fair or judge whether it is fair. The concept of social equity will be different due to factors such as social and cultural background, ideology, personal experience, etc. These uncertainties make post-positivism research methods seem invalid. However, the uncertainty and diversity of the perception of social equity do not mean that social equity is arbitrary. The perception of social equity by different societies or individuals usually fluctuates within a certain range. Individuals or collectives will make judgments on equity issues based on their location of social equity concept in the range. In this thesis, the research on the social equity of R + P development in Hong Kong is to show the situation of different income groups affected by the R + P development in Hong Kong through quantitative data research and to reveal problems, then, to propose the corresponding solutions. This is the basic logic of the entire thesis.

The main products of R + P development are rail and properties. Rail can be further subdivided into tracks and stations. The properties in the early R + P projects are only in the form of residence, while the integrated properties in the later R + P projects appeared in the form of a complex, including office buildings, shopping malls, residences, hotels etc. The R + P development is mainly the integrated development of the rail station and the properties. The integration of rail station and properties is not just a simple combination. The R + P development model includes the integrated development of rail stations and a series of different real estate portfolios. The specific form of each R + P project is adjusted according to the specific conditions of the project. Therefore, the social equity of the R + P development also varies depending on the real estate portfolio of the specific project.

The state of social equity can be quantitatively studied from many angles. The research in this thesis aims to show the social equity of the R + P development from two dimensions: the relationship between the availability of R + P stations and income level and the affordability of R + P residential properties.

R + P development has other impacts on social equity. For example, the noise of rail transit affects residents living near the rail lines. Residents living around the track instead of around the station face losses but do not benefit from the convenience of the proximity to rail station. For rail transit users, the availability of rail stations is also affected by ticket price and carrying capacity. However, these factors affecting social equity are not addressed in this thesis because of limited resources to investigate. In addition, although the form of property in the R + P development model is becoming more and more diversified, the residential properties still account for a considerable part of the R + P development volume, as shown in Table 3. Hong Kong's housing prices have become an important social issue, affecting the wealth gap and social stability in Hong Kong. Information and price data of residential properties are more transparent than other forms of properties. Therefore, considering the availability of research data, the availability of R + P stations and the affordability of R + P residential properties are regarded as the key objects of this thesis.

Table 3

Parameters of some R + P projects

	Tin Hau Station	Tung Chung Station	Kowloon Station	Wong Chuk Hang Station
Completion	1989	1998–2011	1998–2010	2024 (tendering: 2015–20)
Residential	61,000 sq. m. (72.9%)	935,910 sq. m. (90.8%)	608,026 sq. m. (55.5%)	357,500 sq. m. (76.9%)
Retail	3,700 sq. m. (4.4%)	55,862 sq. m. (5.4%)	82,750 sq. m. (7.5%)	47,000 sq. m. (10.1%)
Office	/	14,999 sq. m. (1.5%)	/	/
Hotel	/	22,000 sq. m. (2.1%)	167,472 sq. m. (15.3%)	/
Serviced apartments	/	/	231,778 sq. m. (21.1%)	/
Social welfare	/	/	/	47,000 sq. m. (10.1%)
Transport	/	/	/	58,000 (12.5%)
Other	19,000 sq. m. (22.7%)	2,063 sq. m. (0.2%)	6,163 sq. m. (0.6%)	/

3.4.1 The relationship between the availability of R + P stations and income

3.4.1.1 Fundamental steps

To present the relationship between the availability of R + P stations and income level, this thesis takes four steps. First, in the study of this thesis, it is necessary to clarify the measurement method of the availability of R + P stations; second, to calculate the availability of R + P stations in various districts; third, to sort out the income data of each District Council district; fourth, describe the method of analyzing the relationship between the R + P station availability and income data.

3.4.1.2 The availability of R + P stations

The availability of R + P stations is divided into two categories: the overall R + P station availability of the District Council district and the R + P station availability for the households in the District Council district. The District Council district is explained in 3.4.1.3. Both of two availability calculations assume that the households in the district only have access to the stations in the same district and the stations in the district are only available to the households in the same district. Another assumption is that although R + P stations are different in size, number of entrances and exits etc. in reality, in this thesis, each R + P station is abstracted as a node of the rail transit network, and each R + P node is considered homogeneous. The availability of R + P stations is defined in this thesis as the number of R + P nodes that have access to the rail transit network. For a district, the availability of R + P stations is specifically expressed as the number of R + P stations in the district. For households, the availability of R + P stations is the number of R + P stations in the district evenly allocated to the households. The limitations of these assumptions are discussed later in this thesis. The overall R + P station availability of the District Council district is measured by the number of R + P stations in the district. The more R + P stations in a district, the higher the availability is. Because the number of R + P stations per 1 household is too small, the R + P station availability for the households in the District Council district is measured by the number of R + P stations per 100,000 households in the District Council district, which has similar effect. The smaller the number of households in a district, the bigger the number of R + P stations per 100,000 households in that district if the total number of R + P stations in the district is the same, which means the availability of R + P stations for households in that district is higher. In fact, for the residents of a certain area, the availability of R + P stations also depends on the economy and the distribution of R + P stations in the area etc., but to simplify the analysis, this thesis does not consider these factors. The availability of R + P stations for specific income group is calculated based on the overall availability of R + P stations of the district. The calculation method is discussed in 3.4.1.5.

3.4.1.3 The number and distribution of R + P stations

Hong Kong was divided into 18 District Council districts by the Hong Kong government in 1982. These 18 District Council districts almost remain the same until now, but some of them were split and merged in 1985 and 1994, as stated in Table 4. The application of the R + P development model in Hong Kong began in the 1980s and has a history of decades. Although the Hong Kong District Council districts have been adjusted during this process, the stability of the regional division has almost been maintained. Therefore, in this thesis, data collection, collation and analysis are based on the District Council districts map announced by the Hong Kong Government in 2019. There are currently 10 lines of MTR (excluding light rail and airport express), and 91 stations (interchange stations are not double-counted). According to Cui (2019)'s data, as of 2019, a total of 42 MTR stations have been developed through the

R + P model. Except for Tai Po Market Station, whose development properties are not in the vicinity of the rail station, there are 41 R + P stations. See Table 4 for the distribution of R + P stations in each District Council district.

Table 4

Distribution of R + P stations in 18 District Council districts in Hong Kong						
	District Council districts	**Normal station**	**R+P station**	**No. of R+P stations ($A_{G\cdot x}$)**	**Households number (2019)**	**No. of R+P stations /100,000 households ($A_{R\cdot x}$)**
Hong Kong Island	Central & Western	Kennedy Town. HKU. Sai Ying Pun.	Sheung Wan. Central. Hong Kong. Admiralty.	4	90000	4.4
	Wan Chai	Causeway Bay.	Wan Chai.	1	70200	1.4
	Eastern	North Point. Quarry Bay.	Tin Hau. Fortress Hill. Tai Koo. Sai Wan Ho. Shau Kei Wan. Heng Fa Chuen. Chai Wan.	7	189800	3.7
	Southern	South Horizons. Lei Tung. Ocean Park.	Wong Chuk Hang.	1	86800	1.2
Kowloon	Yau Tsim Mong	East Tsim Sha Tsui. Tsim Sha Tsui. Jordan. Yau Ma Tei. Prince Edward. Mong Kok.	Hung Hom. Mong Kok. Olympic. Kowloon. Austin.	5	127900	3.9
	Sham Shui Po	Mei Foo. Lai Chi Kok. Cheung Sha Wan. Sham Shui Po. Shek Kip Mei	Nam Cheong.	1	154000	0.6
	Kowloon City	Whampoa. Kowloon Tong	Ho Man Tin.	1	147800	0.7
	Wong Tai Sin	Lok Fu, Wong Tai Sin, Diamond Hill	Choi Hung.	1	145200	0.7
	Kwun Tong	Ngau Tau Kok, Kwun Tong, Lam Tin, Yau Tong	Kowloon Bay.	1	245300	0.4
New Territories	Kwai Tsing	Lai King	Tsing Yi. Kwai Hing. Kwai Fong.	3	174400	1.7
	Tsuen Wan	Disneyland Resort. Sunny Bay. Tai Wo Hau.	Tsuen Wan. Tsuen Wan West.	2	110900	1.8
	Tuen Mun	Siu Hong.	Tuen Mun.	1	178800	0.6
	Yuen Long	Tin Shui Wai, Lok Ma Chau	Yuen Long. Long Ping. Kam Sheung Road.	3	223300	1.3
	North	Lo Wu. Sheung Shui. Fanling.	/	/	107900	0.0
	Tai Po	Tai Po Market. Tai Wo.	/	/	103100	0.0
	Sha Tin	University. Racecourse. Sha Tin Wai. City One. Shek Mun. Tai Shui Hang. Heng on. Ma On Shan.	Wu Kai Sha. Fo Tan. Sha Tin. Tai Wai. Che Kung Temple.	5	235100	2.1
	Sai Kung	Po Lam.	Tiu Keng Leng. Tseung Kwan O. Hang Hau. LOHAS Park.	4	155000	2.6
	Islands	/	Tung Chung.	1	68900	1.5

Note:

1. In 1985, Tsuen Wan District was split into Tsuen Wan District and Kwai Tsing District
2. In 1994, Yau Tsim District and Mong Kok District merged into Yau Tsim Mong District

Source:

1.The Census and Statistics Department of Hong Kong Special Administration Region (SAR) government
2.MTRC website: http://www.mtr.com.hk/

3.4.1.4 Income data

The earliest operation of MTRC's rail lines (excluding light rail) is the MTR East Rail Line, which was opened in 1910. The remaining lines were opened after 1979, and the latest is the South Island Line opened in 2016. The development and construction of the MTR network span decades, and the R + P development model began in the 1980s. Because different R +

P stations are opened at different time points, to unify the basis for comparison, the time point of relevant income data is selected as 2019.

The income data is based on households, and the median monthly income of households in various districts of Hong Kong is counted. According to income level, households in each District Council district are divided into three groups (<HK$10,000, HK$10,000-29,999, ≥HK$30,000). The number of households in each income group is counted, as shown in Table 5.

Table 5

Domestic households by District Council district and monthly household income

District Council district		Monthly household income (HK$)			Total	Median monthly household income (HK$)
		<10,000	10,000-29,999	≥30,000		
Central & Western	No.	13,200	20,800	56,000	**90 000**	**41,400**
	%	14.7	23.1	62.2	**100.0**	
Wan Chai	No.	10,300	15,600	44,200	**70 200**	**44,100**
	%	14.7	22.3	63.0	**100.0**	
Eastern	No.	30,300	53,000	106,500	**189 800**	**34,300**
	%	15.9	27.9	56.1	**100.0**	
Southern	No.	13,100	26,600	47,200	**86 800**	**32,800**
	%	15.0	30.6	54.3	**100.0**	
Yau Tsim Mong	No.	23,500	40,000	64,300	**127 900**	**30,000**
	%	18.4	31.3	50.3	**100.0**	
Sham Shui Po	No.	31,400	57,500	65,100	**154 000**	**24,300**
	%	20.4	37.3	42.2	**100.0**	
Kowloon City	No.	25,200	47,100	75,500	**147 800**	**30,000**
	%	17.1	31.8	51.1	**100.0**	
Wong Tai Sin	No.	29,200	52,600	63,500	**145 200**	**25,500**
	%	20.1	36.2	43.7	**100.0**	
Kwun Tong	No.	51,200	99,800	94,300	**245 300**	**22,500**
	%	20.9	40.7	38.4	**100.0**	
Kwai Tsing	No.	34,300	67,400	72,700	**174 400**	**24,700**
	%	19.7	38.6	41.7	**100.0**	
Tsuen Wan	No.	17,700	33,500	59,700	**110 900**	**32,600**
	%	16.0	30.2	53.8	**100.0**	
Tuen Mun	No.	36,800	66,200	75,700	**178 800**	**25,000**
	%	20.6	37.1	42.3	**100.0**	
Yuen Long	No.	43,100	77,100	103,100	**223 300**	**27,000**
	%	19.3	34.5	46.2	**100.0**	
North	No.	21,700	38,100	48,000	**107 900**	**25,800**
	%	20.1	35.3	44.5	**100.0**	
Tai Po	No.	17,100	32,000	54,000	**103 100**	**30,400**
	%	16.6	31.1	52.3	**100.0**	
Sha Tin	No.	41,000	77,000	117,200	**235 100**	**29,700**
	%	17.4	32.8	49.8	**100.0**	
Sai Kung	No.	22,900	40,900	91,200	**155 000**	**36,500**
	%	14.8	26.4	58.8	**100.0**	
Islands	No.	13,400	22,400	33,100	**68 900**	**28,400**
	%	19.5	32.6	48.0	**100.0**	

Source: The Census and Statistics Department of Hong Kong Special Administration Region (SAR) government

3.4.1.5 Analysis of the availability of R + P stations and income data

This thesis conducts two types of analysis to reflect the fairness of the availability of R + P stations, including the distribution of the availability of R + P stations for households with different income, and the correlation between the household income of each District Council district and the R + P station availability of the households in the District Council district.

a. Distribution of the availability of R + P stations for households with different income

This thesis calculates the availability of R + P stations for households in three income groups in each district according to Formula 2.

$$A_{x \cdot Sn} = A_{G \cdot x} \cdot \frac{H_{x \cdot Sn}}{H_x} \qquad (Formula\ 2)$$

Sn *is income group, n = 1, 2, 3. S1, S2, S3 represents three income groups (<HK$10,000, HK$10,000-29,999, ≥HK$30,000) respectively.*
x *represents 18 District Council districts, with values from 1 to 18*
$\boldsymbol{A_{x \cdot Sn}}$ *is the availability of R + P stations of the Sn income group in District Council district x*
$\boldsymbol{A_{G \cdot x}}$ *is the overall availability of R + P stations in District Council district x, that is, the number of R + P stations in the district*
$\boldsymbol{H_{x \cdot Sn}}$ *is the number of households of the Sn income group in District Council district x*
$\boldsymbol{H_x}$ *is the total number of households in District Council district x*

In Formula 2, the availability of R + P stations for an income group in a district equals its proportion of the total number of households in the district multiplied by the overall availability of R + P stations in the district. That is, the income group in the district obtains R + P stations in the district according to its number of households. This is based on the assumptions in 3.4.1.2. The R + P nodes in the district are considered to be evenly allocated to all households in the district, so the larger the proportion of households for an income group in the district, the greater the share of R + P station number in the district allocated to the income group, that is, the higher the share of its the R + P availability in the district.

After calculating the availability of R + P stations for each income group in each district, sum the availability of R + P stations belonging to the same income group in each district according to Formula 3 to obtain the R + P station availability of different income groups in Hong Kong.

$$A_{Sn} = \sum_{1 \le x \le 18} A_{x \cdot Sn} \qquad (Formula\ 3)$$

Based on the calculated A_{S1}, A_{S2}, and A_{S3}, a bar chart is made and presented in *Section 4 Results*, to investigate whether the availability of R + P stations has a particular income group bias.

b. Correlation between the median monthly income of households and the R + P station availability for the households in the district

The R + P station availability for the households in the District Council district is the number of R + P stations per 100,000 households as described above, and is expressed by Formula 4.

$$A_{R\cdot x} = \frac{A_{G\cdot x}}{H_x} \cdot \alpha \qquad (Formula\ 4)$$

***α** = 100,000*
***$A_{R\cdot x}$** is the R + P station availability for the households in the District Council district x*
***$A_{G\cdot x}$** is the overall availability of R + P stations in District Council district x, that is, the number of R + P stations in the district*
***H_x** is the total number of households in the District Council district x*

As discussed in 3.4.1.2, for households, the availability of R + P stations not only depends on the number of R + P stations in the district, but also how many households in the district. Therefore, the indicator reflects the availability of R + P stations for the households in the District Council district through the number of R + P stations per 100,000 households. However, α = 100,000 is not specific. If other numbers such as 1, 1000, or 10000, etc. are used, the result is similar. The availability of R + P stations for households in various districts is shown in Table 4. The median monthly income data of households in various districts is also shown in Table 4.

In this thesis, the Pearson correlation analysis of the availability of R + P stations for households in the district and the income data of households in the corresponding district is carried out and presented in *Section 4 Results*.

3.4.2 The affordability of R + P residential properties

3.4.2.1 Fundamental steps
To study the affordability of R + P residential properties, this thesis takes three steps. First, to clearly define the indicators of the affordability of R + P residential properties. Second, to calculate the price premium for the R + P factor. Third, to describe the analysis method which is applied to the effect of R + P price premium on the affordability of R + P residential properties.

3.4.2.2 The affordability of residential properties
There are many indicators to measure the affordability of housing. This thesis uses income-based indicators to measure the affordability of residential properties, which are the price-to-income ratio (PIR) and housing affordability index (HAI).

Weicher (1977) used the term ‘housing price-income ratio’, which divides the median price of new residential properties by the median household income, to calculate the housing price-income ratio of new residential properties in the United States from 1949 to 1975. This is the beginning of using the affordability indicator in the real estate literature. There are many versions of the definition of the house price to income ratio. This thesis adopts the definition of UN habitat: “ratio of the median free-market price of a dwelling unit and the median annual household income” (UNCHS, 2004).

Based on the median housing price in Hong Kong published by Demographia, and the median monthly income of the households published by the Census and Statistics Department of the Hong Kong government, the house price-to-income ratio in Hong Kong is calculated according to the following Formula 5.

$$PIR = \frac{P}{12I} \qquad (Formula\ 5)$$

P *is the median market value of housing*
I *is the median monthly income of households*

The housing affordability indexes (HAI) that are widely used in various countries are index developed by the National Association of Realtors (NAR) or its variants. In addition to housing prices and household income, this type of index also considers the mortgage interest rate, contractual life of loan, and the upper limit ratio for housing consumption. It is the main tool for judging housing affordability and its changes in real-time. The housing affordability index is calculated by Formula 6.

$$HAI = \frac{I\varphi}{PMT} = \frac{I\varphi}{P \cdot \alpha} \times \frac{\left(1 + \frac{i}{12}\right)^n - 1}{\frac{i}{12} \cdot \left(1 + \frac{i}{12}\right)^n} \qquad (Formula\ 6)$$

I *is the median household monthly income*
φ *represents the upper limit of income for housing consumption*
PMT *is the monthly payment of the mortgage*
P *is the median housing market value of stock*
α *is loan-to-value (LTV) ratio*
i *is the annual mortgage interest rate*
n *(months) indicate contractual life of loan*

In Formula 6, HAI is equal to the monthly income for housing consumption divided by the monthly payment of the mortgage. If the HAI is bigger than 1 or equals 1, which means that the income is sufficient for housing consumptions, the house price affordability is sufficient. If the HAI is less than 1, the household income is not enough to pay for the housing consumptions, and the house price affordability is weak. Formula 6 takes advantage of the formula of capital recovery factor to calculate PMT. Since the period in Formula 6 is 1 month instead of 1 year, the annual mortgage interest rate i is converted into monthly mortgage interest rate i / 12.

Similar to the price-to-income ratio, the median house price data from Demographia and the median monthly household income data from the Census and Statistics Department of Hong Kong government are used.

Regarding the upper limit ratio φ for housing consumption, the US National Housing Act of 1937 and the Housing and Urban-Rural Recovery Act of 1983 set φ = 30% as the housing affordability difficulty standard for low- and middle-income group. Schwartz & Wilson (2008) used φ = 30% - 49.9% as a light housing affordability difficulty indicator and 50% or more as a severe housing affordability difficulty indicator. In the 1990s, Australia used φ = 30% as the housing affordability difficulty indicator for low- and middle-income people (National Housing Strategy, 1991). Mostafa (2006) used φ = 50% as the housing affordability difficulty indicator for the middle-income group in China. This thesis uses the housing cost to income ratio of 50% as severe housing affordability difficulty indicator.

The mortgage interest rates in Hong Kong refer to different benchmark interest rates. According to the December 2019 data of the Hong Kong Monetary Authority, loans for residential use using the Hong Kong Interbank Offered Rate as the pricing reference

accounted for 77.1%, using the Best Lending Rate as the pricing reference was 19.8%, and the other was 3.1%.

With reference to the mortgage interest rates of various commercial banks in Hong Kong[2], this thesis uses a typical value of 2.5% as the annual mortgage loan rate.

The Loan-to-Value (LTV) ratio and the contractual life of loan use average numbers from the Hong Kong Monetary Authority's residential mortgage statistics. The average of the LTV ratio and contractual life of loan for newly approved mortgage loans from January to December 2019 are 48% and 322 months respectively. The data of the whole year is in the Appendix.

3.4.2.3 R + P price premium

Since Cervero and Murakami (2009) have done research on the price premium of R + P, this thesis uses the results after adjustment. They selected Tin Hau, Hang Hau and Tsing Yi stations to study the residential price premium caused by the R + P factor. Tin Hau Station was developed in the early 1980s and was one of the earliest R + P projects. Tsing Yi Station was developed in the 1990s and Hang Hau Station was developed in the early 21st century. These three stations represent R + P projects in different periods. The study uses the hedonic model, which assumes that most consumer goods include a bundle of attributes and that the transaction price can be decomposed into the component (or 'hedonic') prices of each attribute (Rosen, 1974). The coefficient of R + P (that is, R + P attribute price) ranges from HK$263.1-HK$1330.8, which is equivalent to 4.7%-17.4% of the average price of sold R + P units. This thesis adopts the midpoint value of the range as a rational estimate, which is 11%. Therefore, the housing price premium caused by R + P factor is 12.4% (11% / (1-11%) = 12.4%).

3.4.2.4 Analysis methods

Firstly, this thesis calculates the overall PIR and HAI value of Hong Kong based on Formula 5 and Formula 6. Important parameters have been determined in the previous *Section 3.4.2.2*: I = HK$28,700, LTV ratio = 48%, P = HK$7,040,000 is the median market value of the housing, the annual mortgage interest rate is i = 2.5%, and the contractual life of loan is 322 months, the upper limit ratio for housing consumption is set as φ=50%. The calculation results will be presented in *Section 4 Results*. Then, if other conditions remain unchanged, the declined proportion of R + P residential HAI caused by the R + P price premium (12.4%) is analyzed through formula derivation. Finally, Hong Kong's current overall HAI is used as a benchmark, and the benchmark HAI is used to evaluate the impact of R + P price premium on the affordability of R + P residential properties.

[2] https://mortgage.28hse.com/en/bank_offer.html

4 Results

Following the research methods in *Section 3 Methodology Description*, the results are presented in four parts. First, the distribution of the availability of R + P stations in each income group; second, the relationship between household income and the availability of R + P stations for households; third, the price-to-income ratio (PIR) of R + P residential properties; forth, housing affordability index (HAI) of R + P properties.

4.1 The distribution of the availability of R + P stations

Table 6

The availability of R+P stations for different income groups								
District Council district		Monthly household income HK$						Total number of R+P station ($A_{G\cdot x}$)
		<HK$10,000		HK$10,000-HK$29,999		≥HK$30,000		
		% of households	$A_{x\cdot S1}$	% of households	$A_{x\cdot S2}$	% of households	$A_{x\cdot S3}$	
Central & Western		14.7	0.6	23.1	0.9	62.2	2.5	4
Wan Chai		14.7	0.1	22.3	0.2	63	0.6	1
Eastern		15.9	1.1	27.9	2.0	56.1	3.9	7
Southern		15	0.2	30.6	0.3	54.3	0.5	1
Yau Tsim Mong		18.4	0.9	31.3	1.6	50.3	2.5	5
Sham Shui Po		20.4	0.2	37.3	0.4	42.2	0.4	1
Kowloon City		17.1	0.2	31.8	0.3	51.1	0.5	1
Wong Tai Sin		20.1	0.2	36.2	0.4	43.7	0.4	1
Kwun Tong		20.9	0.2	40.7	0.4	38.4	0.4	1
Kwai Tsing		19.7	0.6	38.6	1.2	41.7	1.3	3
Tsuen Wan		16	0.3	30.2	0.6	53.8	1.1	2
Tuen Mun		20.6	0.2	37.1	0.4	42.3	0.4	1
Yuen Long		19.3	0.6	34.5	1.0	46.2	1.4	3
North		20.1	0.0	35.3	0.0	44.5	0.0	0
Tai Po		16.6	0.0	31.1	0.0	52.3	0.0	0
Sha Tin		17.4	0.9	32.8	1.6	49.8	2.5	5
Sai Kung		14.8	0.6	26.4	1.1	58.8	2.4	4
Islands		19.5	0.2	32.6	0.3	48	0.5	1
Overall	Availability of R+P stations (A_{Sn})		7		13		21	41
	Percentage		17.2%		30.8%		52.0%	100%

The R + P station availability for each income group in each district ($A_{x \cdot Sn}$) is calculated according to Formula 2. Then, those $A_{x \cdot Sn}$ are added up by the three income groups (<HK$10,000, HK$10,000-29,999, ≥HK$30,000) according to Formula 3, results as shown in Table 6.

According to the availability of R + P stations of each income group, a bar chart is made as shown in Figure 2.

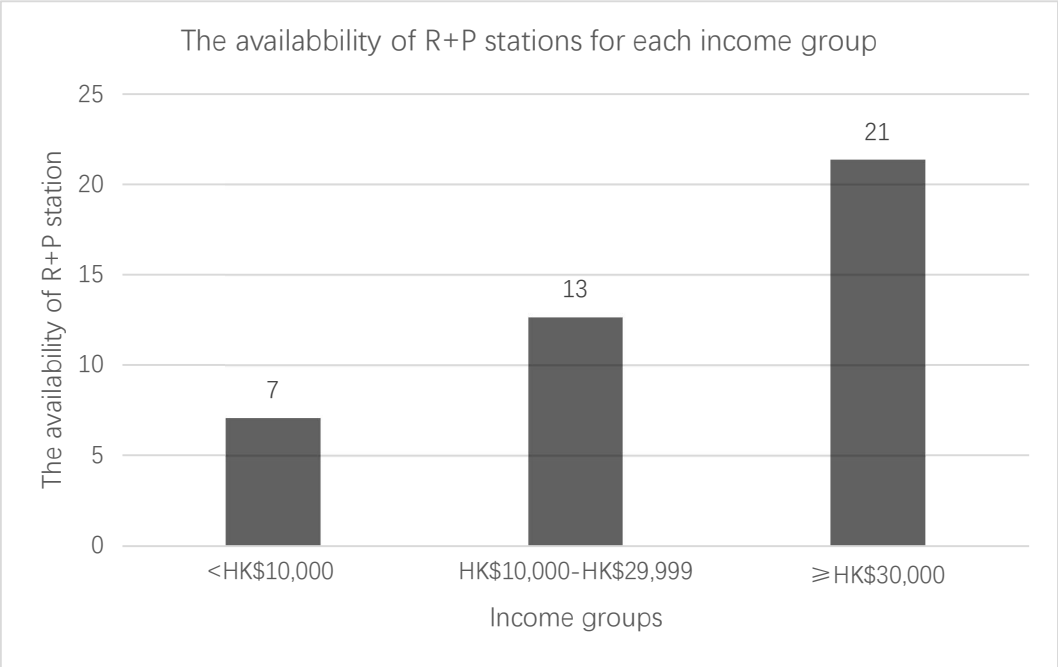

Figure 2

The overall monthly median household income in Hong Kong in 2019 is HK $ 28,700. The income group with income below the median includes roughly two income groups of < HK$10,000 and HK$10,000-29,999. Therefore, this thesis combines these two income groups into low- and middle-income group. The ≥ HK$30,000 group is referred as higher income group.

The availability of R + P stations for each income group in Hong Kong means that, after considering the distribution of R+ P stations in District Council districts, the number of R + P nodes allocated to each income group. As can be seen from Figure 2, the number of R + P station for the < HK$10,000 income group is 7, 13 for the HK$10,000-29,999 income group, and 21 for the ≥ HK$30,000 income group. The availability of R + P stations for low- and middle-income groups is lower than that of higher income group. This result is obvious, but it does not indicate that the R + P availability of different income groups is unfair. There are reasons: **a.** The class interval of the three income groups is not equal. The class interval of <HK$10,000 group is 10,000, the class interval of the HK$10,000-29,999 group is 20,000, and the class interval of ≥HK$30,000 group is theoretically infinite. Differences in the class interval are part of the reasons for differences in the availability of R + P stations for each

income group. Since the division of class interval is set by the original data source, the Census and Statistics Department of Hong Kong government, this thesis adopts it directly. **b.** The availability of R + P stations in each income group calculated by the Formula 2 depends on the demographic structure of households and the number of R + P stations in each district. Therefore, the number of households in each income group affects the distribution of the availability of R + P stations for each income group. That is to say, if the R + P stations are evenly distributed in each district, the fewer households in an income group, the smaller the availability of R + P stations for that income group is. The difference in the availability of R + P stations by income groups does not demonstrate the unfairness.

In order to overcome the above two problems, Figure 3 is introduced. Figure 3 uses two indicators, Percentage of availability and Percentage of households, both of which are structural indicators and are more comparable. Percentage of availability refers to the proportion of the R + P station availability for a certain income group to society's overall R + P station availability. For example, the calculation method of Percentage of availability of <HK$10,000 group is 7 / (7 + 13 + 21) * 100% = 17.2%. Percentage of households is the proportion of households to the total number, that is, the number of households of certain income group to the total number of households in society.

The analysis method for Figure 3 is to compare whether the Percentage of availability and Percentage of households of each income group match or not. If the consistency of the two indicators is high, that is, the income group with a larger number of households should have higher R + P station availability, it indicates a high degree of matching. This high consistency theoretically means better equity situation.

As can be seen from Figure 3, the overall distribution of the two indicators is very similar, both of which are the lowest in the <HK$10,000 group, the second in the HK$10,000-29,999 group, and the highest in the ≥HK$30,000 group. However, upon further observation, it can be found that the Percentage of availability in groups <HK$10,000 and HK$10,000-29,999 are 1% and 2.4% lower than Percentage of households respectively, and the Percentage of availability in the group ≥HK$30,000 is 3.4% higher than Percentage of households. These results show that the availability of R + P stations in the low- and middle-income group is lower than the proportion of their households, while the availability of R + P stations in the higher income group is higher than the proportion of their households. After excluding the class interval problem and the structural factors of the number of households, it is found that the higher income group still obtain extra R + P station availability, while the low- and middle-income group has less R + P station availability.

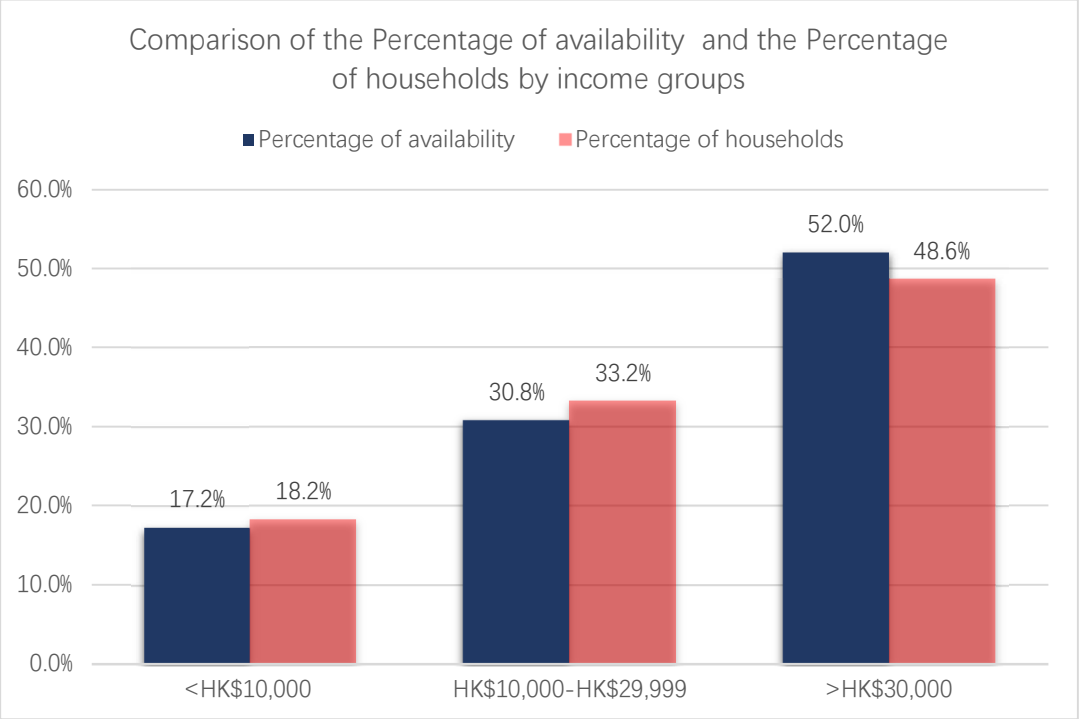

Figure 3

4.2 Correlation analysis

The availability of R + P stations for households in the district ($A_{R \cdot x}$) is calculated according to Formula 4, the results are as shown in Table 4. Then, by utilizing the median monthly household income data of each district in Table 5, a correlation analysis is performed between the two indicators to obtain the correlation coefficients shown in Table 7

Table 7

Results of Correlation Analysis

		R+P stations/100k households	median monthly income
R+P stations / 100k households	Pearson Correlation	1	.562*
	Sig. (2-tailed)		.015
	N	18	18
*. Correlation is significant at the 0.05 level (2-tailed).			

The results of the correlation analysis show that $A_{R \cdot x}$ has a significant positive correlation with the median monthly household income at the 0.05 level, and the correlation coefficient is 0.562. It should be noted that correlation analysis cannot explain causality. The results of correlation analysis demonstrate that households in the district with a higher median monthly income usually have higher R + P station availability. However, the scatterplot Figure 4 also shows the existence of outliers. For example, the median household income in the Wan Chai District is HK$44,100, which is the highest among 18 District Council districts, whereas the number of R + P stations per 100,000 households in Wan Cai District is only 1.4, which is similar to the Island district with a median household income of only HK$28,400.

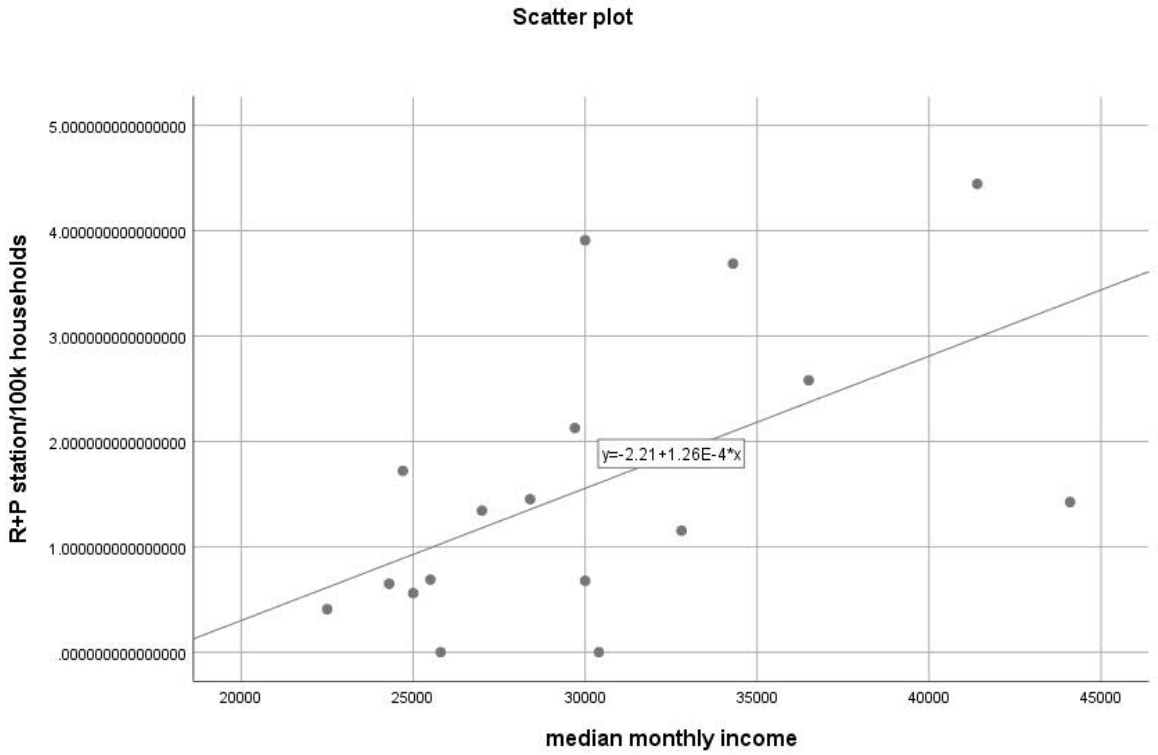

Figure 4

4.3 Price-to-income ratio of R + P residential properties

The overall PIR of Hong Kong and the PIR of R + P residential properties is calculated in accordance with Formula 5. Using Demographia's median house price data in 3rd Quarter 2019 and the monthly household income data in 2019 published by the Census and Statistics Department of Hong Kong, the overall PIR = 7,040,000 / (12 * 28,700) = 20.4, which is very close to 20.8 calculated by Demographia. According to the Demographia international housing affordability survey 2020, Hong Kong's PIR is the highest among 92 major markets in the world, and it is 74.8% higher than that of the second-highest city Vancouver (PIR=11.9). According to the results inferred from the study of Cervero and Murakami (2009), the R + P factor causes the average price of the R + P residential properties to be 12.4% higher than that of the non-R + P residential properties. The house price-to-income ratio of the R + P residential properties also increases by the same proportion, 12.4%, reaching 23.0, which is more than double that of Vancouver. The PIR indicator reflects that Hong Kong's overall affordability of housing prices ranks last among the 92 major markets in the world, and the affordability of R + P residential properties is even weaker than the overall situation.

4.4 Housing Affordability Index of the R + P residential properties

The overall HAI and the HAI of R + P residential properties are calculated in accordance with Formula 6. The overall HAI of Hong Kong, based on the data from the Census and Statistics Department of Hong Kong and the Hong Kong Monetary Authority, can be calculated as HAI = 0.995 if it is assumed that households can spend 50% of their monthly income on housing expenses. The overall HAI of Hong Kong is 0.995, which is basically 1. This result indicates that the overall affordability of housing in Hong Kong is sufficient. This

result is different compared with the result obtained by using PIR, mainly for two reasons: **a.** HAI considers the loan factor. The lower loan interest rate and the longer contractual life of loan have the effect of improving HAI. **b.** 50% is selected as the φ value.

The R + P factor causes the price of the R + P residential properties to rise by 12.4%, thereby the HAI of the R + P residential properties is different (Cervero and Murakami, 2009). Assuming that other data remain unchanged, the HAI of the R + P residential properties is calculated according to Formula 6, HAI = 0.886, which is less than 1, and has decreased about 11% compared with the overall situation. It should be noted that when calculating the HAI of R + P residential properties, other variables can change in the long term in reality. The higher prices of R + P residential properties are likely to result in higher loan ratio α, which can reduce HAI. Contrary to the loan ratio α, higher house prices can lead to longer loan term n, which in turn can increase HAI. The changes in these two parameters depend on the monetary policies and market situation, which lead to uncertainty of HAI changes. Considering the availability of loans does not change due to R + P factors in the short term, this thesis assumes that variables except for housing price remain unchanged. The calculation result of HAI of R + P residential properties shows that the R + P factor makes the affordability of R + P residential properties decreased, which is similar as the results that PIR indicated. The difference is that the overall HAI is equal to 1, whereas HAI of R + P residential properties is less than 1. This result demonstrates that, for low- and middle-income groups, the overall residence in Hong Kong is affordable, while R + P residential properties are not affordable.

5 Discussion

5.1 Research questions and results

The construction and operation of Hong Kong's rail transit are financially successful, one of the main reasons is that the R + P development model has been widely adopted. Many scholars have conducted detailed studies on the economic significance of R + P development. However, very little literature has been found to focus on the social equity of Hong Kong's R + P development model. The goal of this thesis is to explore the social equity of R + P development by studying the availability of R + P stations and the affordability of R + P residential properties. The results of the study show that: **a.** The distribution of the availability of R + P stations is more conducive to higher income group, and the availability of R + P stations for households has a significant positive correlation with the household income level of the districts where they are located. **b.** Both the PIR and HAI indicate R + P residential properties are less affordable than overall residence for low- and middle-income households in Hong Kong. PIR indicates that middle-income households are under great pressure to pay for R + P residential properties. HAI of residential properties indicates that low- and middle-income households cannot afford R + P residential properties, whereas overall HAI shows overall residence is affordable for low- and middle-income household.

5.2 Possible explanation

The results of the study clearly demonstrate the significant correlation between income and the availability of R + P stations. The reason for this phenomenon is complex. In the districts with high R + P station availability, there are better public transportation conditions, higher land value, and higher housing prices and cost of living. These factors have crowded out low- and middle-income groups while attracted higher income households. In addition, the improvement of traffic conditions can attract more and better job opportunities, which can increase the income level of the districts. Moreover, R + P development model finances the construction and operation of rail transit. It is necessary to capture the value of the lands and properties surrounding the rail transit station as much as possible. Due to the price premium of the R + P properties, when selecting the location for R + P development projects, areas with insufficient housing affordability may be excluded, making the availability of R + P stations related to household income levels. These reasons need further research.

The reason for the lack of affordability of R + P residential properties is even more complicated. First of all, Hong Kong's overall housing price level is at the forefront of the world. Second, the price premium caused by the R + P factor further weakens the affordability of R + P residential properties.

The reason why the R + P factor can have price premium may be that the integrated development of R + P further improves the public transport accessibility of the residential properties, resulting in the higher value of residential properties. In addition, in order to capture value as much as possible, the developer of R + P residential properties may adopt a high premium strategy.

5.3 Resulting problems and corresponding countermeasures

The significant correlation between the availability of Hong Kong's R + P stations and income level reveals the problem of biased allocation of public services among different

income groups. Low- and middle-income group is at a disadvantage in the distribution of R + P stations, even though they may be more dependent on public transportation. According to Tang *et al*.'s study (2004), the government transferred the land to the MTRC at the pre-development price which is relatively low. The MTRC obtained asset appreciation gains through the R + P development, thereby financing rail transit construction and operation. Rail transit is a public transportation facility, and the company has obtained the low-price lands provided by government for the construction and operation, so the availability of rail services involves the distribution of public interest. The major public transportation infrastructure should not only consider economic and efficiency issues when choosing a development model, but should also consider whether the distribution of public resources is fair or not. The distribution of public interest should make all groups benefit similarly, rather than benefiting specific groups. The problem of bias in the distribution of R + P station availability among different income groups disclosed in this thesis is complicated, but this may be an inevitable result of the market mechanism because the market mechanism emphasizes efficiency rather than equity. The biased distribution of R + P station availability in different income groups may cause mobility disadvantage of low- and middle- income group because Hong Kong residents is highly dependent on public transportation, as mentioned in the *Section 1 Introduction*. The mobility disadvantage can affect career opportunities, the convenience of life etc., which can further deteriorate the income level and quality of life of low- and middle-income group, thereby causing a greater gap between rich and poor.

Solving the problem of public resource allocation may require government intervention. The government can use its monopoly position in urban planning to correct possible social equity issues, but whether there are social equity issues, whether they need to be corrected, and how to correct them requires more researches.

Hong Kong's low- and middle-income households cannot afford R + P residential properties, which may also lead to social equity issues. Low- and middle-income group usually relies more on public transportation, and the price premium of R + P factor weakens the ability of low- and middle-income group to pay for R + P residential properties. As a result, low- and middle-income group may have to live farther away from rail transit stations. There is an efficiency problem because resource allocation is not optimal. On the other hand, the price premium of R + P residential properties makes low- and middle-income group live farther away from the R + P station, further weakening the R + P station availability of low- and middle-income group.

Regarding the problem of insufficient affordability of R + P residential properties, the solutions can be considered from three aspects. The first is to increase income, which involves a wide range of policies. The second is to provide a certain percentage of public housing in the integrated residential part of R + P development. The third is financial support, such as extending the contractual life of loan and providing interest subsidies etc.

5.4 Limitations and future research directions

5.4.1 Limitations

When calculating the availability of R + P stations, it is assumed that households in a certain district only have access to rail stations in the same district and rail stations in the district are

only available to residents in the district. However, the movement routes of residents are not fixed in reality. Residents may use rail transit stations in other regions for purposes of shopping, working, education etc. The rail stations in other districts can also be used by residents living in different districts and even foreigners. Some R + P stations are located at the junction of two districts and are shared by the two districts. In addition, this thesis assumes that the R + P station is the abstract node of the rail transit network, and each node is homogeneous, which simplifies the analysis. However, R + P stations are different in reality. Factors such as the location of the station, the number of platforms, the number and location of entrances and exits, and the floor area of the station etc. affect how and whether residents can use the R + P station. The differences between assumptions and reality can cause deviations in the results. Moreover, both calculating the availability of R + P stations for each income group and doing correlation analysis between household income and the availability of R + P stations for households in the district are based on the 18 District Council districts. Therefore, the geographical division of the 18 District Council districts affects the results. Finally, the class interval of income groups set by the Census and Statistics Department of Hong Kong is directly used. With only three income groups, the availability of R + P stations for households with different incomes is not fully reflected, which affects the comparison between different income groups.

For the price premium of the R + P factor, this thesis directly uses the research results of Cervero and Murakami (2009)'s study to infer the price premium value, which has an uncertain effect on the accuracy of the HAI and PIR indicators. Cervero and Murakami (2009)'s article was published in 2009, which is a long time ago. Secondly, their study draws the conclusions about R + P price premium with data of only 3 R + P stations. Whether other R + P stations have similar conclusions need further studies. In addition, the inference of the R + P price premium directly uses the midpoint, which may also cause deviations.

5.4.2 Future research directions

The research in this thesis only reveals part of the social equity situation of the R + P development in Hong Kong. It only involves the availability of R + P stations and the affordability of R + P residential properties, which is far from reflecting the whole picture of the social equity of the R + P development in Hong Kong. During the entire life cycle of R + P projects, from planning, land acquisition, design, construction to later operation and maintenance, there is the distribution of benefits or damages between different groups. There are widespread social equity issues during the entire life cycle. In addition to the social equity problems caused by the affordability of R + P residential properties, R + P official properties may also result in social equity problems because of differences in employment opportunities. Besides, R + P commercial real estate may lead to differences in urban service, thereby causing other social equity issues. These problems require further researches.

6 Conclusion

The development of Hong Kong's rail transit has been economically successful, and its widely adopted R + P development model has been discussed by many scholars. However, very few studies focus on the social equity of the R + P development model. R + P stations and R + P residential properties are important products of the R + P development. The main idea of this thesis is to quantitatively study the availability of R + P stations for different income groups and the affordability of R + P residential properties. The results partly reflect the social equity of the R + P model for different income groups and reveal resulting problems. Then, this thesis proposes possible countermeasures. It is found that higher income group has higher availability of R + P stations, and the availability of R + P stations for households has a positive correlation with the household income level of the districts where the they live. These results are consistent with hypotheses. In addition, the higher income group has extra R + P station availability after excluding the demographic structural factors, which shows the biased distribution of R + P station availability toward higher income group. This is a result obtained outside of the hypotheses. This study also finds that the affordability of R + P residential properties in Hong Kong is worse than that of overall residences, which is consistent with the hypothesis. The HAI indicator further illustrates that households with low- and middle- income cannot afford R + P residential properties.

The availability of R + P stations is a matter of public resource allocation. The bias in its distribution among different income groups may lead to social equity issues, further causing greater gap between the rich and the poor. In addition, the lack of affordability of R + P residential properties can force the income groups that rely on public transportation to live farther away from the R + P stations, resulting in an inefficient social resource allocation. The lack of affordability of R + P residential properties can further deteriorate the availability distribution of R + P stations.

This thesis proposes measures that have the potential to improve the current social equity situation of R + P development in Hong Kong. Firstly, public authority can utilize its monopoly position of urban planning to optimize the distribution of public resources and promote the equity of allocation. Besides, some adjustments to the R + P development model can be made to encourage provision of some economical public R + P housing while capturing the land value to finance rail transit network. Moreover, adjusting financial policies to provide financial support to vulnerable groups is conducive to improving the affordability of low- and middle-income groups to R + P residential properties.

Overall, the research results of this thesis reflect the disadvantages of low- and middle-income groups in using R + P stations and acquiring R + P residential properties in Hong Kong, thus reveals part of the social equity issues of the R + P development. It shows another aspect of Hong Kong's R + P development beyond its economic success. The methods adopted in this thesis are limited to the availability of data, and a lot of simplifications have been made. If there is more data available in the future, better methods can be used to draw more reliable conclusions. In addition, although this thesis attempts to explore the reasons and propose countermeasures for the problems reflected in the research, further researches are needed to confirm the rationality of those explanations and the effectiveness of those countermeasures. There are many other problems affecting social equity throughout the entire life cycle of the R + P integrated development process. Other forms of real estate of the R + P integrated development can also cause social equity issues. More academic

researches focusing on the social equity of R + P development in Hong Kong are needed, which can promote R + P development towards comprehensive sustainability.

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Appendix

LTV ratio and Contractual life of newly approved mortgage loans from January to December 2019		
Month (Year 2019)	Loan-to-value (LTV) ratio	Contractual life of new loan approved (month)
1	46.00%	316
2	47.70%	322
3	47.80%	320
4	48.00%	320
5	47.10%	319
6	47.40%	323
7	46.20%	321
8	46.50%	322
9	45.90%	323
10	48.00%	319
11	51.20%	327
12	53.40%	327
Average	48%	322

Source: The Residential Mortgage Statistics of Hong Kong Monetary Authority, 2019